(12) UK Patent (19) GB (11) 2 381 019 (13) B

(45) Date of publication: 29.12.2004

(54) Title of the invention: Apparatus and method for isolation of subterranean zones

(51) Int Cl^7: **E21B** 43/10 29/00 33/12 33/124 // **E21B** 43/12 43/14

(21) Application No: **0219757.2**

(22) Date of Filing: **23.08.2002**

(30) Priority Data:
(31) **09981916** (32) **18.10.2001** (33) **US**

(60) Parent of Application No(s)
0422893.8 under Section 15(4) of the Patents Act 1977

(43) Date A Publication: **23.04.2003**

(52) UK CL (Edition W):
E1F FKF FLA FLW FMU

(56) Documents Cited:
GB 2370301 A
GB 2344606 A
EP 1152120 A
US 20020066576 A1
GB 2348657 A
GB 2343691 A
US 20020148612 A1

(58) Field of Search:
As for published application 2381019 A *viz:*
UK CL (Edition V) **E1F** FKA FKF FLA FLW FMU
INT CL^7 **E21B** 29/00 33/00 33/12 33/122 33/124 43/10 43/12 43/14 43/16
Other: **Online: EPODOC, JAPIO, WPI, TXTEP, TXTGB, TXTUS, TXTWO.**
updated as appropriate

(72) Inventor(s):
Robert Lance Cook
Michael L Bullock

(73) Proprietor(s):
Enventure Global Technology
(Incorporated in USA - Delaware)
16200 A Park Row, Houston, Texas 77084, United States of America

(74) Agent and/or Address for Service:
Haseltine Lake & Co
Redcliff Quay, 120 Redcliff Street, BRISTOL, BS1 6HU, United Kingdom

1/4

2381019

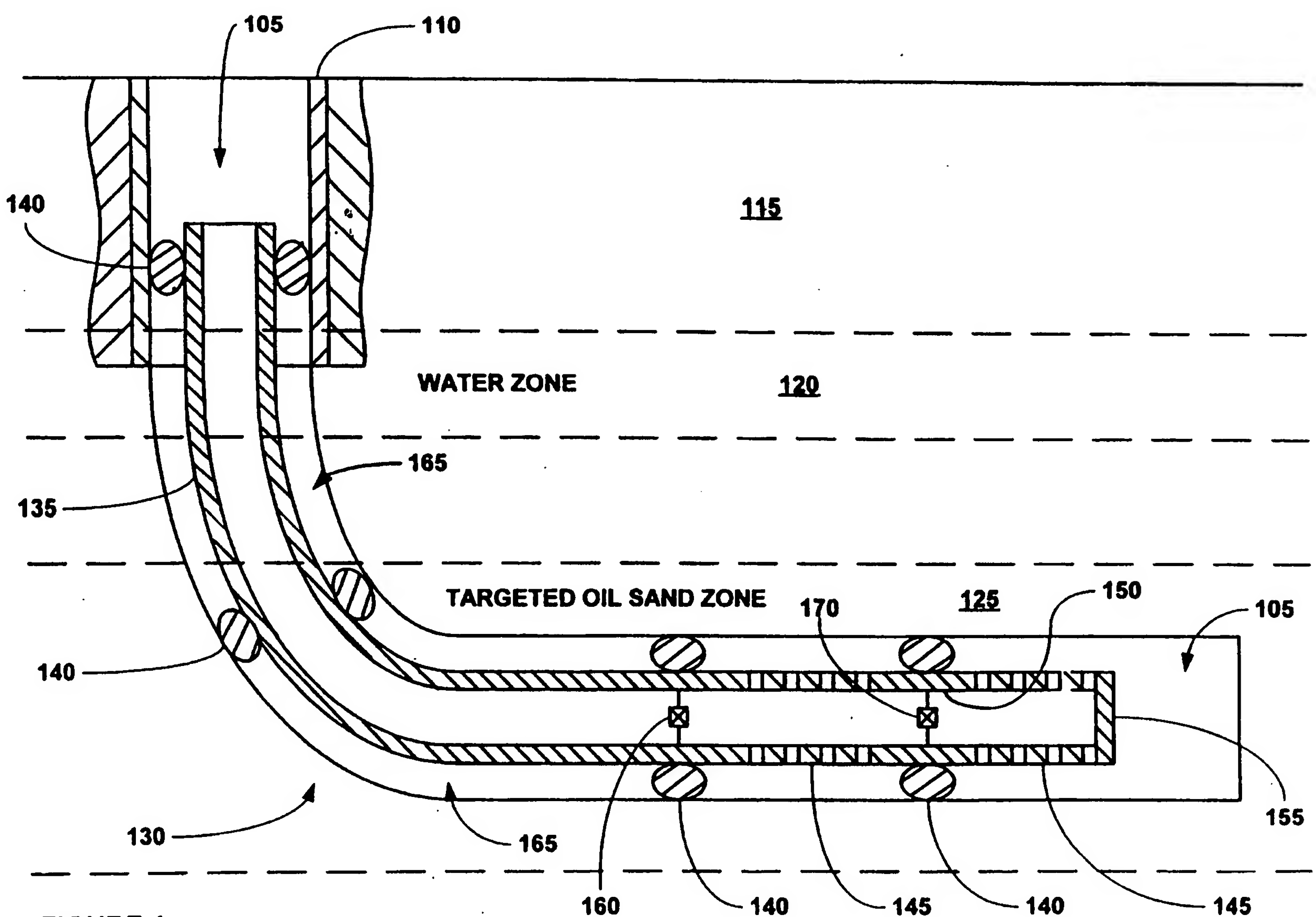


FIGURE 1

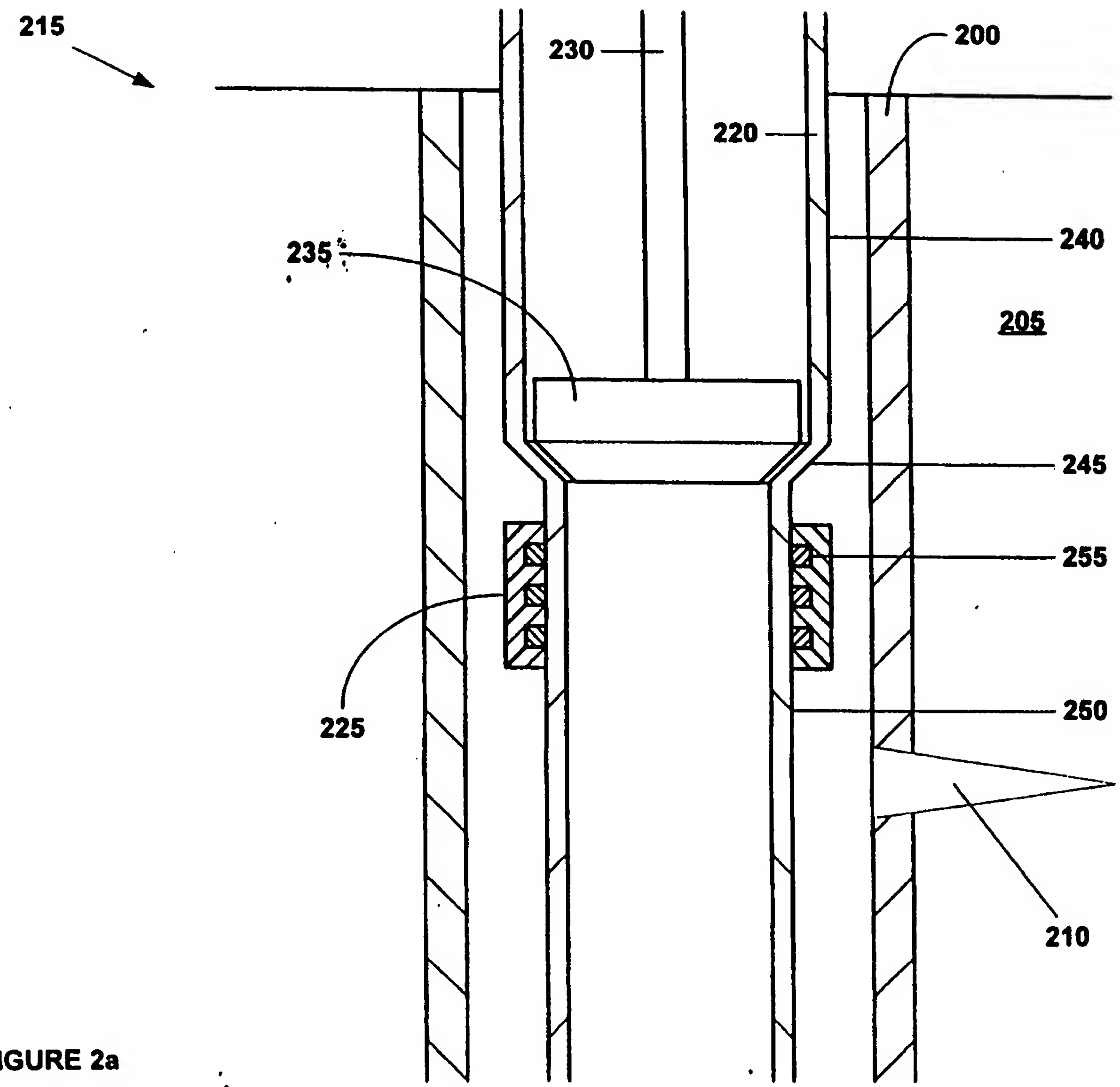


FIGURE 2a

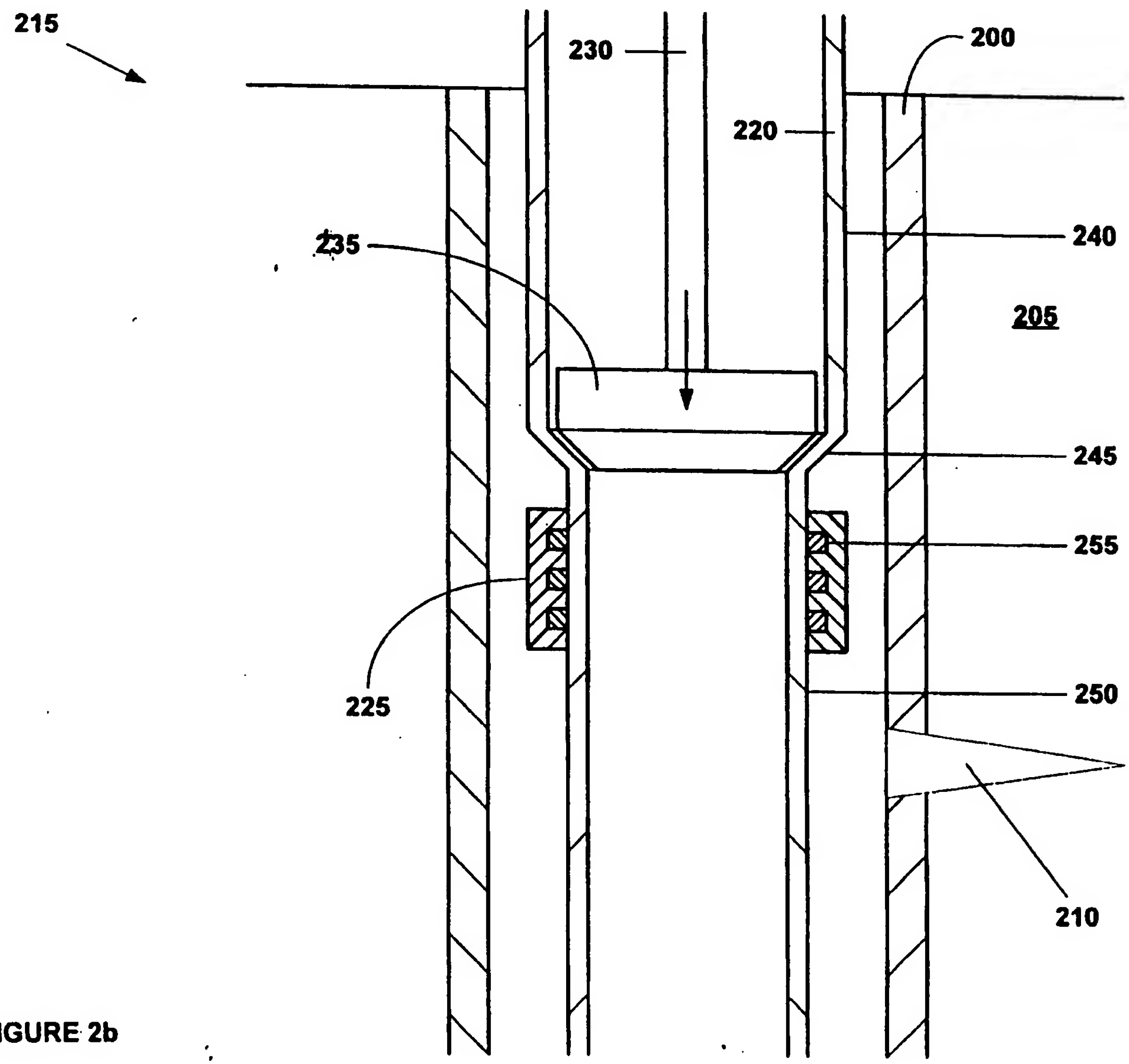


FIGURE 2b

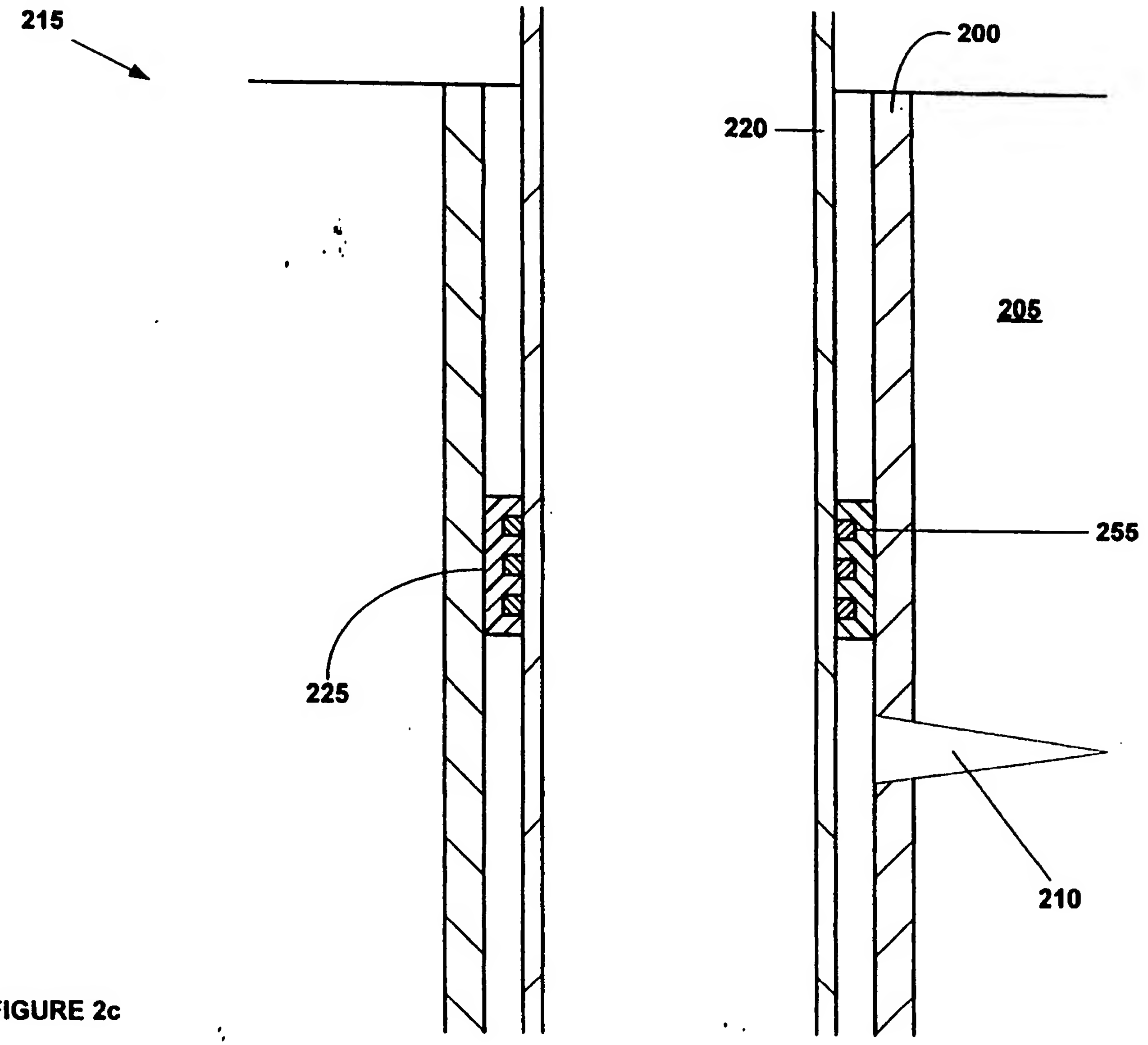


FIGURE 2c

238/019

APPARATUS AND METHOD FOR ISOLATION OF SUBTERRANEAN ZONES

Background of the Invention

This invention relates generally to oil and gas exploration, and in particular to isolating certain subterranean zones to facilitate oil and gas exploration.

During oil exploration, a wellbore typically traverses a number of zones within a subterranean formation. Some of these subterranean zones will produce oil and gas, while others will not. Further, it is often necessary to isolate subterranean zones from one another in order to facilitate the exploration for and production of oil and gas. Existing methods for isolating subterranean production zones in order to facilitate the exploration for and production of oil and gas are complex and expensive.

The present invention is directed to overcoming one or more of the limitations of the existing processes for isolating subterranean zones during oil and gas exploration.

Summary of the Invention

According to a first aspect of the present invention there is provided an apparatus, comprising:

a packer positioned within a tubular apparatus including:

a radially expanded tubular member; and

one or more sealing members coupled to the outer surface of the radially expanded tubular member to provide a sealing mechanism between the tubular apparatus and the radially expanded tubular member.

Preferably, the tubular apparatus further comprises:

one or more solid tubular members, each solid tubular member including one or more external seals;

one or more perforated tubular members coupled to the solid tubular members;

a shoe coupled to one of the perforated tubular members; and

one or more intermediate solid tubular members coupled to and interleaved among the perforated tubular members, each intermediate solid tubular member including one or more external seals, the packer positioned within one or more of the solid, perforated, and intermediate tubular members.

Preferably, the apparatus further comprises one or more valve members.

Preferably, one or more of the intermediate solid tubular members include one or more valve members.

Preferably, the tubular apparatus further comprises one or more primary solid tubulars, each primary solid tubular including one or more external annular seals;

n perforated tubulars coupled to the primary solid tubulars;

n-1 intermediate solid tubulars coupled to and interleaved among the perforated tubulars, each intermediate solid tubular including one or more external annular seals;

a shoe coupled to one of the perforated tubulars; and

the packer positioned within one or more of the solid, perforated, and intermediate tubulars.

Preferably, the radially expanded tubular member comprises a radially expanded perforated tubular member.

Preferably, the radially expanded tubular member is adapted to be positioned within a wellbore casing.

Preferably, the apparatus further comprises a wellbore that traverses a subterranean formation;

the tubular apparatus further comprising one or more solid tubular members positioned within the wellbore, each solid tubular member comprising one or more external seals that engage the wellbore;

an annulus defined between one or more of the solid tubular members and the wellbore;

the tubular apparatus further comprising one or more non-solid tubular members that permit fluidic materials to pass therethrough into the annulus coupled to the solid tubular members;

a shoe coupled to one of the non-solid tubular members,

the packer being positioned within one or more of the solid and non-solid tubular members.

Preferably, the apparatus further comprises a wellbore that traverses a subterranean formation;

the tubular apparatus further comprising one or more primary solid tubulars positioned within the wellbore, each primary solid tubular including one or more external annular seals that engage the wellbore;

an annulus defined between the primary solid tubulars and the wellbore;

the tubular apparatus further comprising n non-solid tubulars that permit fluidic materials to pass therethrough into the annulus coupled to the primary solid tubulars;

the tubular apparatus further comprising n-1 intermediate solid tubulars coupled to and interleaved among the non-solid tubulars, each intermediate solid tubular including one or more external annular seals that engage the wellbore;

a shoe coupled to one of the other tubulars,

the packer of being positioned within one or more of the solid and non-solid tubulars.

There is also provided a method of isolating a first subterranean zone from a second subterranean zone in a wellbore, comprising:

positioning one or more primary solid tubulars within the wellbore, the primary solid tubulars traversing the first subterranean zone;

positioning one or more secondary tubulars within the wellbore, the secondary tubulars traversing the second subterranean zone;

fluidicly coupling the secondary tubulars and the solid tubulars;

preventing the passage of fluids from the first subterranean zone to the second subterranean zone within the wellbore external to the solid and secondary tubulars; and

fluidicly isolating one or more annular regions within one or more of the tubulars using the apparatus according to the first aspect of the invention,

wherein the secondary tubulars permit fluidic material to pass therethrough in a radial direction.

There is also provided a method of extracting materials from a producing subterranean zone in a wellbore, at least a portion of the wellbore including a casing, comprising;

positioning one or more primary solid tubulars within the wellbore;

fluidicly coupling the primary solid tubulars with the casing;

positioning one or more secondary tubulars within the wellbore, the secondary tubulars traversing the producing subterranean zone;

fluidicly coupling the secondary tubulars with the solid tubulars;

fluidicly isolating the producing subterranean zone from at least one other subterranean zone within the wellbore;

fluidicly coupling at least one of the secondary tubulars with the producing subterranean zone; and

fluidicly isolating one or more annular regions within one or more of the tubulars using the apparatus according to the first aspect of the invention,

wherein the secondary tubulars permit fluidic materials to pass therethrough in a radial direction.

The method further comprises controllably fluidicly decoupling at least one of the secondary tubulars from at least one other of the secondary tubulars.

There is also provided a method of isolating a first subterranean zone from a second subterranean zone in a wellbore, comprising:

positioning one or more primary solid tubulars within the wellbore, the primary solid tubulars traversing the first subterranean zone;

defining an annulus between the primary solid tubulars and the wellbore;

positioning one or more non-solid tubulars within the wellbore that permit fluidic materials to pass therethrough into the annulus, the non-solid tubulars traversing the second subterranean zone;

fluidicly coupling the solid and non-solid tubulars;

preventing the passage of fluids from the first subterranean zone to the second subterranean zone within the wellbore external to the solid and other tubulars; and

fluidicly isolating one or more annular regions within one or more of the tubulars using the apparatus according to the first aspect of the invention.

There is also provided method of extracting materials from a producing subterranean zone in a wellbore, at least a portion of the wellbore including a casing, comprising;

positioning one or more primary solid tubulars within the wellbore;

fluidicly coupling the primary solid tubulars with the casing;

defining an annulus between the solid tubulars and the wellbore;

positioning one or more non-solid tubulars within the wellbore that permit fluidic materials to pass therethrough into the annulus, the non-solid tubulars traversing the producing subterranean zone;

fluidicly coupling the non-solid tubulars with the solid tubulars;

fluidicly isolating the producing subterranean zone from at least one other subterranean zone within the wellbore;

fluidicly coupling at least one of the non-solid tubulars with the producing subterranean zone; and

fluidicly isolating one or more annular regions within one or more of the tubulars using the apparatus according to the first aspect of the invention.

Brief Description of the Drawings

The invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a fragmentary cross-sectional view illustrating the isolation of subterranean zones.

FIG. 2a is a fragmentary cross-sectional illustration of an embodiment of an apparatus for fluidicly isolating annular regions within a wellbore casing.

FIG. 2b is a fragmentary cross-sectional illustration of the apparatus of FIG. 2a after initiating the axial displacement of the expansion cone.

FIG. 2c is a fragmentary cross-sectional illustration of the apparatus of FIG. 2b after completion of the radial expansion process.

Detailed Description of the Illustrative Embodiments

An apparatus and method for isolating one or more subterranean zones from one or more other subterranean zones is provided. The apparatus and method permits a producing zone to be isolated from a nonproducing zone using a combination of solid and slotted tubulars. In the production mode, the teachings of the present disclosure may be used in combination with conventional, well known, production completion equipment and methods using a series of packers, solid tubing, perforated tubing, and sliding sleeves, which will be inserted into the disclosed apparatus to permit the commingling and/or isolation of the subterranean zones from each other.

An apparatus and method for providing a packer for use in isolating one or more subterranean zones from one or more subterranean zones is also provided. The apparatus and method permit a packer to be provided by radially expanding a tubular member including one or more outer sealing members into engagement with a preexisting tubular structure.

Referring to Fig. 1, a wellbore 105 including a casing 110 is positioned in a subterranean formation 115. The subterranean formation 115 includes a number of productive and non-productive zones, including a water zone 120 and a targeted oil sand zone 125. During exploration of the subterranean formation 115, the wellbore 105 may be extended in a well known manner to traverse the various productive and non-productive zones, including the water zone 120 and the targeted oil sand zone 125.

In order to fluidicly isolate the water zone 120 from the targeted oil sand zone 125, an apparatus 130 is provided that includes one or more sections of solid casing 135, one or more external seals 140, one or more sections of slotted casing 145, one or more intermediate sections of solid casing 150, and a solid shoe 155.

The solid casing 135 provides a fluid conduit that transmits fluids and other materials from one end of the solid casing 135 to the other end of the solid casing 135. The solid casing 135 may comprise any number of conventional commercially available sections of solid tubular casing such as, for example, oilfield tubulars fabricated from chromium steel or fiberglass. The solid casing 135 comprises oilfield tubulars available from various foreign and domestic steel mills.

The solid casing 135 is coupled to the casing 110. The solid casing 135 may be coupled to the casing 110 using any number of conventional commercially available processes such as, for example, welding, slotted and expandable connectors, or expandable solid connectors. In a preferred embodiment, the solid casing 135 is coupled to the casing 110 by using expandable solid connectors. The solid casing 135 may comprise a plurality of such solid casing 135.

The solid casing 135 is coupled to one more of the slotted casings 145. The solid casing 135 may be coupled to the slotted casing 145 using any number of conventional commercially available processes such as, for example, welding, or slotted and expandable connectors. In a preferred embodiment, the solid casing 135 is coupled to the slotted casing 145 by expandable solid connectors.

The casing 135 includes one more valve members 160 for controlling the flow of fluids and other materials within the interior region of the casing 135. Alternatively, during the production mode of operation, an internal tubular string with various arrangements of packers, perforated tubing, sliding sleeves, and valves may be employed within the apparatus to provide various options for commingling and isolating subterranean zones from each other while providing a fluid path to the surface.

The casing 135 is placed into the wellbore 105 by expanding the casing 135 in the radial direction into intimate contact with the interior walls of the wellbore 105. The casing 135 may be expanded in the radial direction using any number of conventional commercially available methods.

The seals 140 prevent the passage of fluids and other materials within the annular region 165 between the solid casings 135 and 150 and the wellbore 105. The seals 140 may comprise any number of conventional commercially available sealing materials suitable for sealing a casing in a wellbore such as, for example, lead, rubber or epoxy. In a preferred embodiment, the seals 140 comprise Stratalok epoxy material available from Halliburton Energy Services.

The slotted casing 145 permits fluids and other materials to pass into and out of the interior of the slotted casing 145 from and to the annular region 165. In this manner, oil and gas may be produced from a producing subterranean zone within a subterranean formation. The slotted casing 145 may comprise any number of conventional commercially available sections of slotted tubular casing. Preferably, the slotted casing 145 comprises expandable slotted tubular casing available from Petroline in Aberdeen, Scotland. Most preferably, the slotted casing 145 comprises expandable slotted sandscreen tubular casing available from Petroline in Aberdeen, Scotland.

The slotted casing 145 is coupled to one or more solid casing 135. The slotted casing 145 may be coupled to the solid casing 135 using any number of conventional commercially available processes such as, for example, welding, or slotted or solid expandable connectors. Preferably, the slotted casing 145 is coupled to the solid casing 135 by expandable solid connectors.

The slotted casing 145 is coupled to one or more intermediate solid casings 150. The slotted casing 145 may be coupled to the intermediate solid casing 150 using any number of conventional commercially available processes such as, for example, welding or expandable solid or slotted connectors. Preferably, the slotted casing 145 is coupled to the intermediate solid casing 150 by expandable solid connectors.

The last slotted casing 145 is coupled to the shoe 155. The last slotted casing 145 may be coupled to the shoe 155 using any number of conventional commercially available processes such as, for example, welding or expandable solid or slotted connectors. Preferably, the last slotted casing 145 is coupled to the shoe 155 by an expandable solid connector.

In an alternative embodiment, the shoe 155 is coupled directly to the last one of the intermediate solid casings 150.

The slotted casings 145 are positioned within the wellbore 105 by expanding the slotted casings 145 in a radial direction into intimate contact with the interior walls of the wellbore 105. The slotted casings 145 may be expanded in a radial direction using any number of conventional commercially available processes.

The intermediate solid casing 150 permits fluids and other materials to pass between adjacent slotted casings 145. The intermediate solid casing 150 may comprise any number of conventional commercially available sections of solid tubular casing such as, for example, oilfield tubulars fabricated from chromium steel or fiberglass. The intermediate solid casing 150 comprises oilfield tubulars available from foreign and domestic steel mills.

The intermediate solid casing 150 is coupled to one or more sections of the slotted casing 145. The intermediate solid casing 150 may be coupled to the slotted casing 145 using any number of conventional commercially available processes such as, for example, welding, or solid or slotted expandable connectors. Preferably, he intermediate solid casing 150 is coupled to the slotted casing 145 by expandable solid connectors. The intermediate solid casing 150 may comprise a plurality of such intermediate solid casing 150.

Each intermediate solid casing 150 includes one more valve members 170 for controlling the flow of fluids and other materials within the interior region of the intermediate casing 150. In an alternative embodiment, as will be recognized by persons having ordinary skill in the art and the benefit of the present disclosure, during the production mode of operation, an internal tubular string with various arrangements of packers, perforated tubing, sliding sleeves, and valves may be employed within the apparatus to provide various options for commingling and isolating subterranean zones from each other while providing a fluid path to the surface.

The intermediate casing 150 is placed into the wellbore 105 by expanding the intermediate casing 150 in the radial direction into intimate contact with the interior walls of the wellbore 105. The intermediate casing 150 may be expanded in the radial direction using any number of conventional commercially available methods.

One or more of the intermediate solid casings 150 may be omitted. One or more of the slotted casings 145 are provided with one or more seals 140.

The shoe 155 provides a support member for the apparatus 130. In this manner, various production and exploration tools may be supported by the shoe 150. The shoe 150 may comprise any number of conventional commercially available shoes suitable for use in a wellbore such as, for example, cement filled shoe, or an aluminum or composite shoe. Preferably, the shoe 150 comprises an aluminum shoe available from Halliburton. The shoe 155 is selected to provide sufficient strength in compression and tension to permit the use of high capacity production and exploration tools.

The apparatus 130 includes a plurality of solid casings 135, a plurality of seals 140, a plurality of slotted casings 145, a plurality of intermediate solid casings 150, and a shoe 155. More generally, the apparatus 130 may comprise one or more solid casings 135, each with one or more valve members 160, n slotted casings 145, n-1 intermediate solid casings 150, each with one or more valve members 170, and a shoe 155.

During operation of the apparatus 130, oil and gas may be controllably produced from the targeted oil sand zone 125 using the slotted casings 145. The oil and gas may then be transported to a surface location using the solid casing 135. The use of intermediate solid casings 150 with valve members 170 permits isolated sections of the zone 125 to be selectively isolated for production. The seals 140 permit the zone 125 to be fluidicly isolated from the zone 120. The seals 140 further permits isolated sections of the zone 125 to be fluidicly isolated from each other. In this manner, the apparatus 130 permits unwanted and/or non-productive subterranean zones to be fluidicly isolated.

As will be recognized by persons having ordinary skill in the art and also having the benefit of the present disclosure, during the production mode of operation, an internal tubular string with various arrangements of packers, perforated tubing, sliding sleeves, and valves may be employed within the apparatus to provide various options for commingling and isolating subterranean zones from each other while providing a fluid path to the surface.

Referring to FIGS, 2a, 2b, and 2c, a preferred embodiment of a method and apparatus for fluidicly isolating a section of a wellbore casing will be described. Referring to Fig. 2a, a wellbore casing 200 is positioned within a subterranean formation 205. The wellbore casing 200 may be positioned in any orientation from the vertical direction to the horizontal direction. The wellbore casing 200 further includes one or more openings 210 that may have been, for example, the result of: (1)

unintentional damage to the wellbore casing 200, (2) a prior perforation or fracturing operation performed upon the surrounding subterranean formation 205, or (3) a slotted section of the wellbore casing 200. As will be recognized by persons having ordinary skill in the art, the openings 210 can affect the subsequent operation and use of the wellbore casing 200 unless they are fluidicly isolated from other regions within the wellbore casing 200. An apparatus 215 is utilized to fluidicly isolate openings 110 within the wellbore casing 100.

The apparatus 215 includes an expandable tubular member 220, one or more sealing members 225, a support member 230, and an expansion cone 235.

The expandable tubular member 220 is adapted to be supported from above by conventional support members. The expandable tubular member 220 is further coupled to the sealing members 225 and movably coupled to the expansion cone 235. The expandable tubular member 220 includes an upper section 240, an intermediate section 245, and a lower section 250. The upper and intermediate sections, 240 and 245, are adapted to mate with the expansion cone 235. The wall thickness of the lower section 250 is less than the wall thickness of the upper and intermediate sections, 240 and 245.

In several alternative embodiments, the expandable tubular member 220 includes one or more slotted portions to permit the passage of fluidic materials from the interior to the exterior of the expandable tubular member 220. In this manner, production fluids may be conveyed to and from the annular region between the expandable tubular member 220 and the wellbore casing 200.

The sealing members 225 are coupled to the outer surface of the expandable tubular member 220. The sealing members 225 are adapted to fluidicly seal the interface between the radially expanded tubular member 220 and the wellbore casing 200. In this manner, the opening 210 is fluidicly isolated from other sections of the wellbore casing. The apparatus 215 includes a plurality of sealing members 225, positioned above and below the position of the opening 210 in order to surround and completely fluidicly isolate the opening 210. The sealing members 225 may be any number of conventional sealing members. The sealing members 225 include one or more reinforcing inner rings 255.

The support member 230 is adapted to be supported from above by conventional support members. The support member 230 is further coupled to the expansion cone 235.

The expansion cone 235 is coupled to the support member 230. The expansion cone 235 is further movably coupled to the expandable tubular member 220. The expansion cone 235 is adapted to radially expand the expandable tubular member 220 when axially displaced relative to the expandable tubular member 220.

As illustrated in FIG. 2a, the apparatus 215 is positioned within the wellbore casing 200 at a predetermined position relative to the opening 210. During placement of the apparatus 215, the expandable tubular member 220 and the support member 230 are supported and positioned using conventional support and positioning equipment.

As illustrated in FIG. 2b, in a preferred embodiment, the expansion cone 235 is then axially displaced relative to the expandable tubular member 220. The axial displacement of the expansion cone 235 radially expands the expandable tubular member 220. The expandable tubular member 220 is radially expanded by about 8 to 40 %.

As illustrated in FIG. 2c, after completing the radial expansion of the expandable tubular member 220, the annular region between the radially expanded tubular member 220 and the wellbore casing 200 is fluidicly sealed by the sealing members 225. In this manner, the openings 210 are fluidicly isolated from other sections of the wellbore casing 200.

The ratio of the unexpanded portion of the expandable tubular member 220 to the inside diameter of the wellbore casing 200 ranges from about 8 to 40 %. In this manner, the expandable tubular member 220 can be easily positioned within and through collapsed sections of the wellbore casing 200.

The ratio of the inside diameter of the radially expanded tubular member 220 to the inside diameter of the wellbore casing 200 ranges from about 8 to 40 %. In this manner, a large passage is provided within the expanded tubular member 220 for the passage of additional production tools and/or production fluids and gases.

Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

1. An apparatus, comprising:

a packer positioned within a tubular apparatus including:

a radially expanded tubular member; and

one or more sealing members coupled to the outer surface of the radially expanded tubular member to provide a sealing mechanism between the tubular apparatus and the radially expanded tubular member.

2. The apparatus of claim 1, the tubular apparatus further comprising;

one or more solid tubular members, each solid tubular member including one or more external seals;

one or more perforated tubular members coupled to the solid tubular members;

a shoe coupled to one of the perforated tubular members; and

one or more intermediate solid tubular members coupled to and interleaved among the perforated tubular members, each intermediate solid tubular member including one or more external seals, the packer positioned within one or more of the solid, perforated, and intermediate tubular members.

3. The apparatus of claim 2, further comprising one or more valve members.

4. The apparatus of claim 2, wherein one or more of the intermediate solid tubular members include one or more valve members.

5. The apparatus of claim 1, the tubular apparatus further comprising:

one or more primary solid tubulars, each primary solid tubular including one or more external annular seals;

n perforated tubulars coupled to the primary solid tubulars;

n-1 intermediate solid tubulars coupled to and interleaved among the perforated tubulars, each intermediate solid tubular including one or more external annular seals;

a shoe coupled to one of the perforated tubulars; and

the packer positioned within one or more of the solid, perforated, and intermediate tubulars.

6. The apparatus of claim 1, wherein the radially expanded tubular member comprises a radially expanded perforated tubular member.

7. The apparatus of claim 6, wherein:

the radially expanded tubular member is adapted to be positioned within a wellbore casing.

8. The apparatus of claim 1, further comprising:

a wellbore that traverses a subterranean formation;

the tubular apparatus further comprising one or more solid tubular members positioned within the wellbore, each solid tubular member comprising one or more external seals that engage the wellbore;

an annulus defined between one or more of the solid tubular members and the wellbore;

the tubular apparatus further comprising one or more non-solid tubular members that permit fluidic materials to pass therethrough into the annulus coupled to the solid tubular members;

a shoe coupled to one of the non-solid tubular members,

the packer being positioned within one or more of the solid and non-solid tubular members.

9. The apparatus of claim 1, further comprising:

a wellbore that traverses a subterranean formation;

the tubular apparatus further comprising one or more primary solid tubulars positioned within the wellbore, each primary solid tubular including one or more external annular seals that engage the wellbore;

an annulus defined between the primary solid tubulars and the wellbore;

the tubular apparatus further comprising n non-solid tubulars that permit fluidic materials to pass therethrough into the annulus coupled to the primary solid tubulars;

the tubular apparatus further comprising n-1 intermediate solid tubulars coupled to and interleaved among the non-solid tubulars, each intermediate solid tubular including one or more external annular seals that engage the wellbore;

a shoe coupled to one of the other tubulars,

the packer of being positioned within one or more of the solid and non-solid tubulars.

10. A method of isolating a first subterranean zone from a second subterranean zone in a wellbore, comprising:

positioning one or more primary solid tubulars within the wellbore, the primary solid tubulars traversing the first subterranean zone;

positioning one or more secondary tubulars within the wellbore, the secondary tubulars traversing the second subterranean zone;

fluidicly coupling the secondary tubulars and the solid tubulars;

preventing the passage of fluids from the first subterranean zone to the second subterranean zone within the wellbore external to the solid and secondary tubulars; and

fluidicly isolating one or more annular regions within one or more of the tubulars using the apparatus of claim 1,

wherein the secondary tubulars permit fluidic material to pass therethrough in a radial direction.

11. A method of extracting materials from a producing subterranean zone in a wellbore, at least a portion of the wellbore including a casing, comprising;

positioning one or more primary solid tubulars within the wellbore;

fluidicly coupling the primary solid tubulars with the casing;

positioning one or more secondary tubulars within the wellbore, the secondary tubulars traversing the producing subterranean zone;

fluidicly coupling the secondary tubulars with the solid tubulars;

fluidicly isolating the producing subterranean zone from at least one other subterranean zone within the wellbore;

fluidicly coupling at least one of the secondary tubulars with the producing subterranean zone; and

fluidicly isolating one or more annular regions within one or more of the tubulars using the apparatus of claim 1,

wherein the secondary tubulars permit fluidic materials to pass therethrough in a radial direction.

12. The method of claim 11, further comprising:

controllably fluidicly decoupling at least one of the secondary tubulars from at least one other of the secondary tubulars.

13. A method of isolating a first subterranean zone from a second subterranean zone in a wellbore, comprising:

positioning one or more primary solid tubulars within the wellbore, the primary solid tubulars traversing the first subterranean zone;

defining an annulus between the primary solid tubulars and the wellbore;

positioning one or more non-solid tubulars within the wellbore that permit fluidic materials to pass therethrough into the annulus, the non-solid tubulars traversing the second subterranean zone;

fluidicly coupling the solid and non-solid tubulars;

preventing the passage of fluids from the first subterranean zone to the second subterranean zone within the wellbore external to the solid and other tubulars; and

fluidicly isolating one or more annular regions within one or more of the tubulars using the apparatus of claim 1.

14. A method of extracting materials from a producing subterranean zone in a wellbore, at least a portion of the wellbore including a casing, comprising;

positioning one or more primary solid tubulars within the wellbore;

fluidicly coupling the primary solid tubulars with the casing;

defining an annulus between the solid tubulars and the wellbore;

positioning one or more non-solid tubulars within the wellbore that permit fluidic materials to pass therethrough into the annulus, the non-solid tubulars traversing the producing subterranean zone;

fluidicly coupling the non-solid tubulars with the solid tubulars;

fluidicly isolating the producing subterranean zone from at least one other subterranean zone within the wellbore;

fluidicly coupling at least one of the non-solid tubulars with the producing subterranean zone; and

fluidicly isolating one or more annular regions within one or more of the tubulars using the apparatus of claim 1.

(12) UK Patent (19) GB (11) 2 382 367 (13) B

(45) Date of publication: 22.09.2004

(54) Title of the invention: Coupling an expandable liner to a wellbore casing

(51) Int Cl[7]: **E21B** 23/00 23/08 29/00 43/10

(21) Application No: **0300085.8**

(22) Date of Filing: **27.07.2001**

(30) Priority Data:
(31) **60221645** (32) **28.07.2000** (33) **US**

(60) Parent of Application No(s)
0416834.0 under Section 15(4) of the Patents Act 1977

(86) International Application Data:
PCT/US2001/023815 En 27.07.2001

(87) International Publication Data:
WO2002/010550 En 07.02.2002

(43) Date A Publication: **28.05.2003**

(52) UK CL (Edition W):
E1F FLA

(56) Documents Cited:

US 6085838 A	**US 6012522 A**
US 5494106 A	**US 3353599 A**
US 2812025 A	**US 2796134 A**

(58) Field of Search:
As for published application 2382367 A *viz:*
Other: **U.S. : 166/207, 277, 381, 383;**
Online: DERWENT, JPO, EPO
updated as appropriate

(72) Inventor(s):
Robert Lance Cook
Lev Ring

(73) Proprietor(s):
Enventure Global Technology
(Incorporated in USA - Delaware)
16200 A Park Row, Houston, Texas 77084, United States of America

(74) Agent and/or Address for Service:
Haseltine Lake & Co
Redcliff Quay, 120 Redcliff Street, BRISTOL, BS1 6HU, United Kingdom

2382367

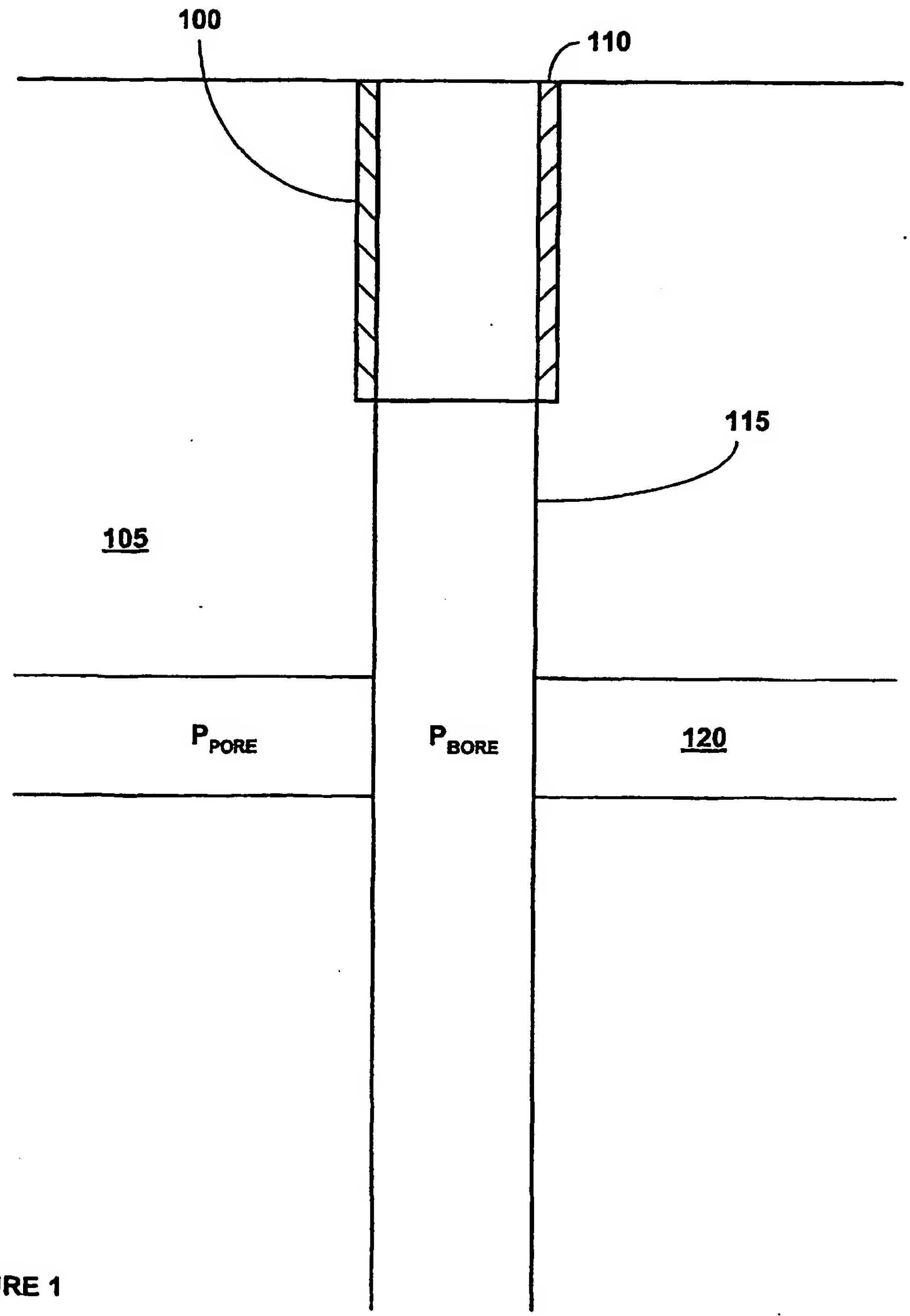
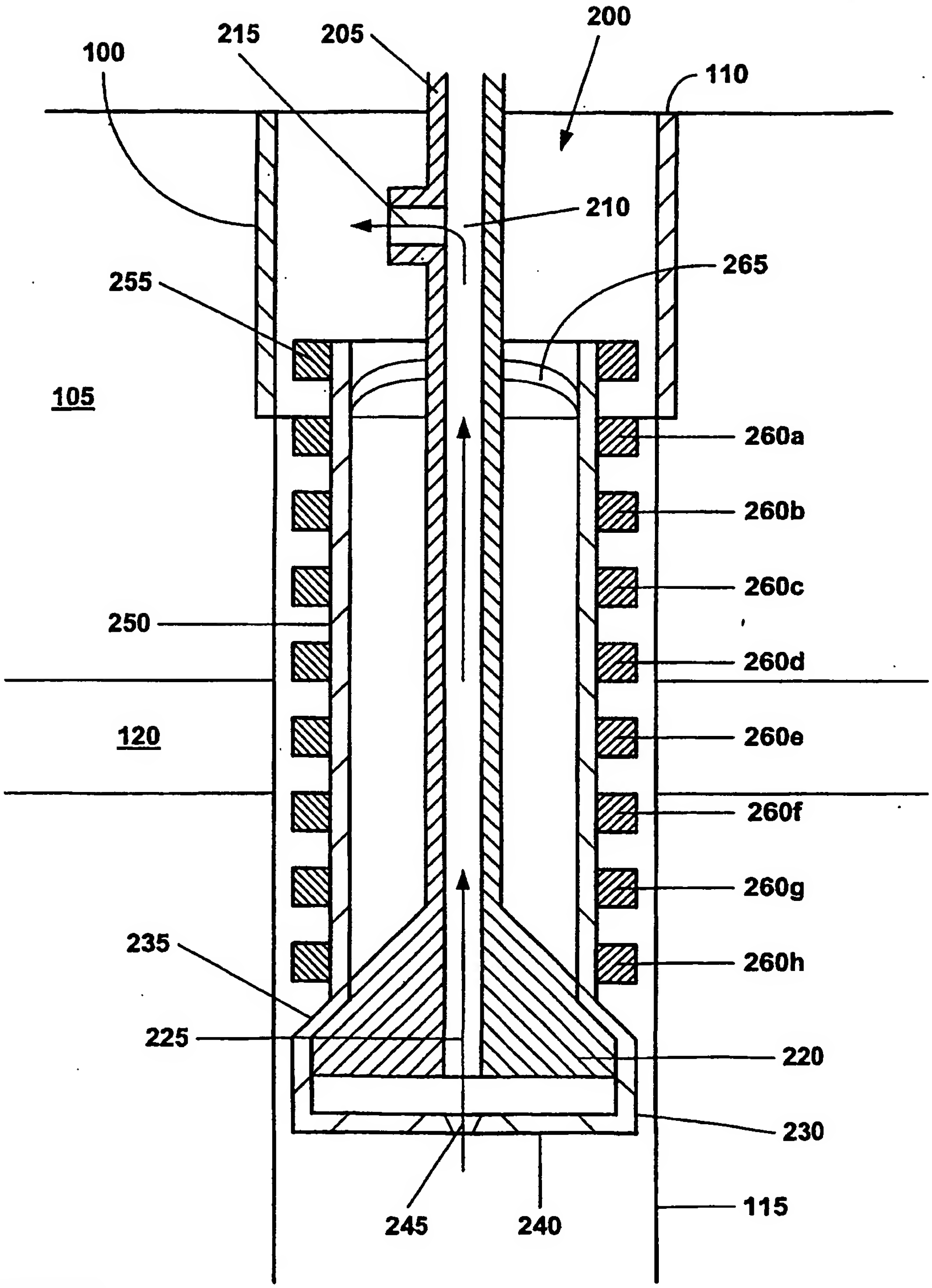


FIGURE 1



100
215
205
200
110
210
255
265
105
260a
260b
260c
250
260d
120
260e
260f
260g
235
260h
225
220
230
245
240
115

FIGURE 2

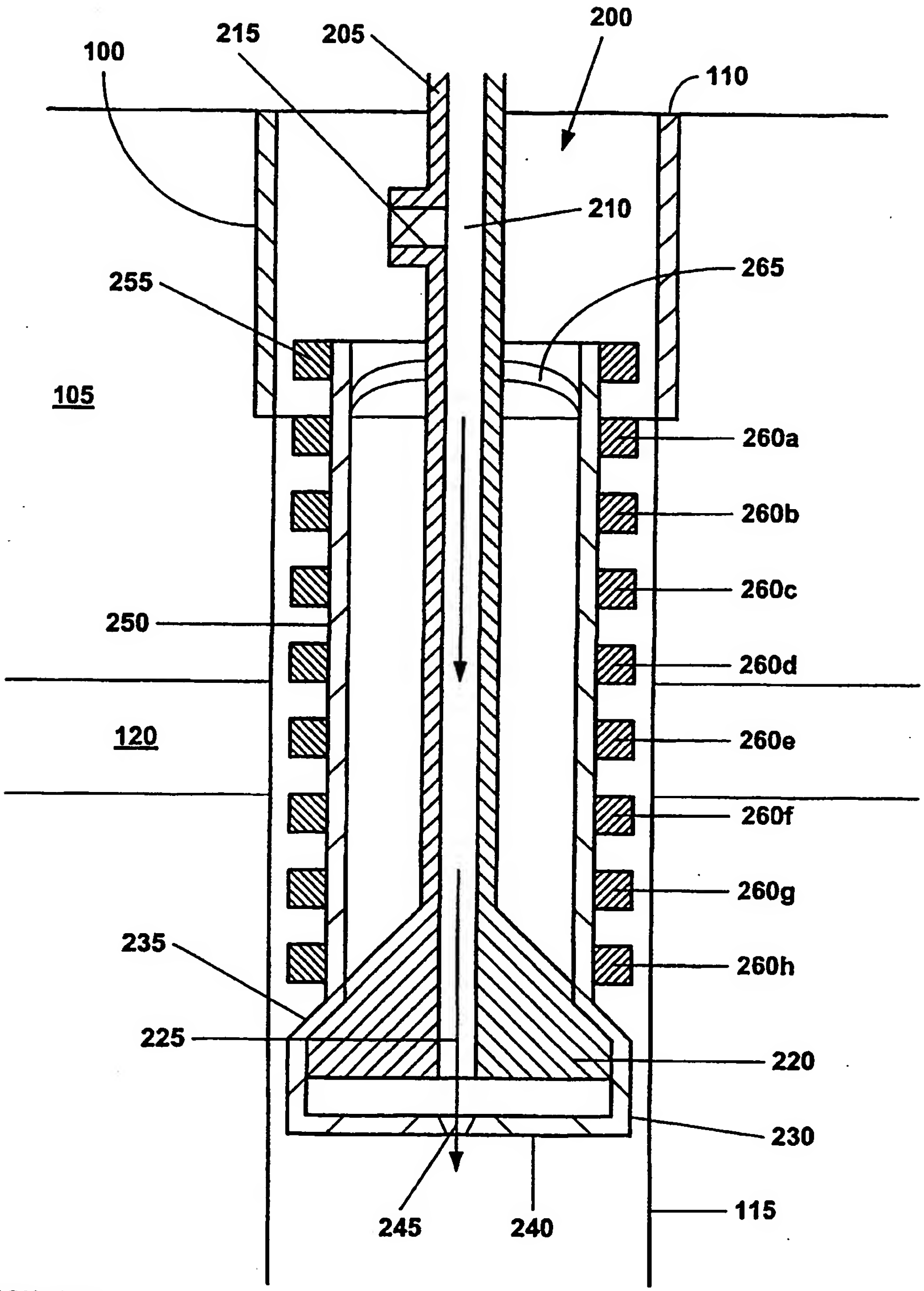
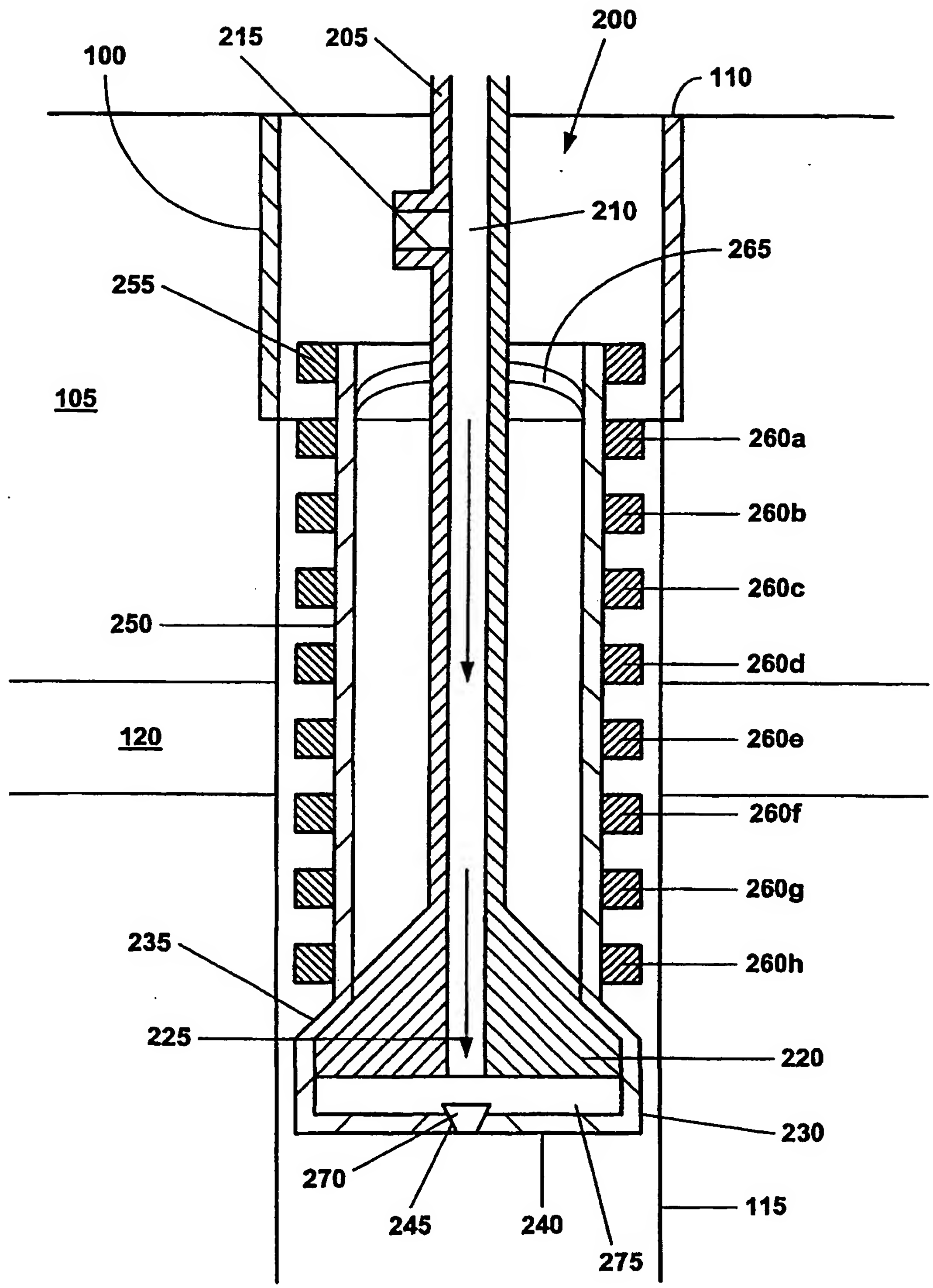

100
215
205
200
110
210
265
255
105
260a
260b
260c
250
260d
120
260e
260f
260g
235
260h
225
220
230
245
240
115

FIGURE 3



100
215
205
200
110
210
265
255
105
260a
260b
260c
250
260d
120
260e
260f
260g
235
260h
225
220
230
270
245
240
275
115

FIGURE 4

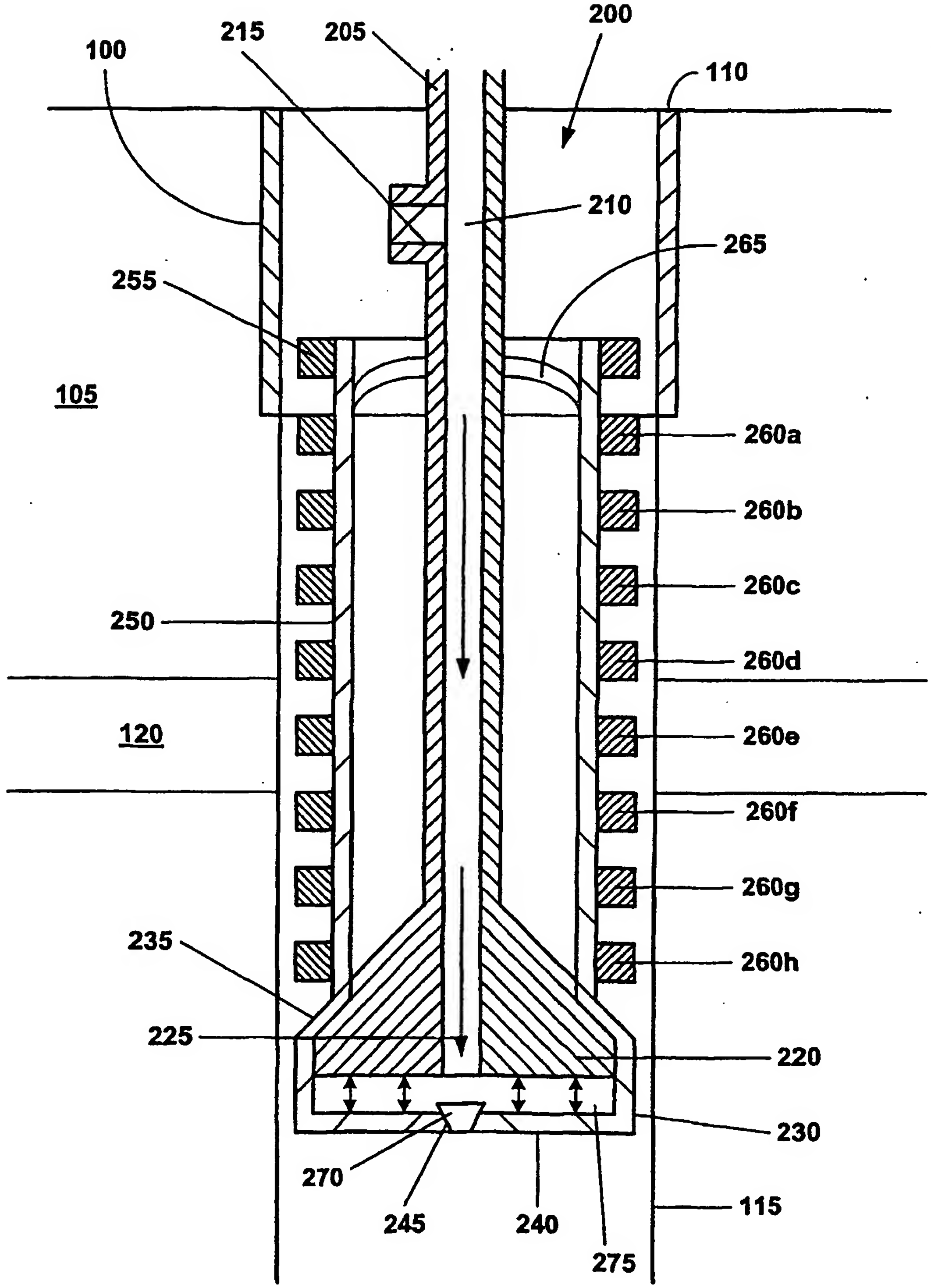

100
215
205
200
110
210
265
255
105
260a
260b
260c
250
260d
120
260e
260f
260g
235
260h
225
220
230
270
245
240
115
275

FIGURE 5

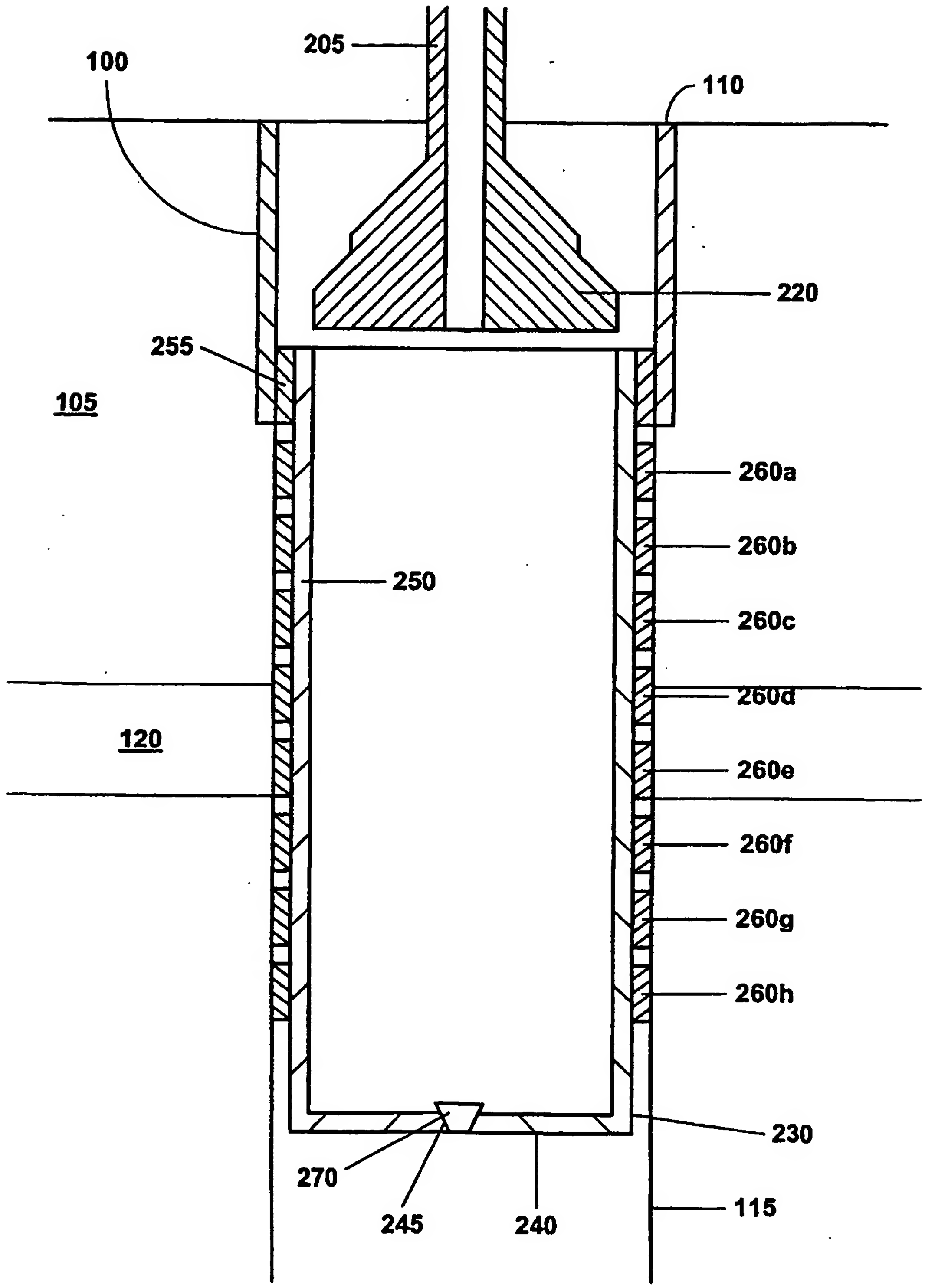

205
100
110
220
255
105
260a
260b
250
260c
260d
120
260e
260f
260g
260h
230
270
245
240
115

FIGURE 6

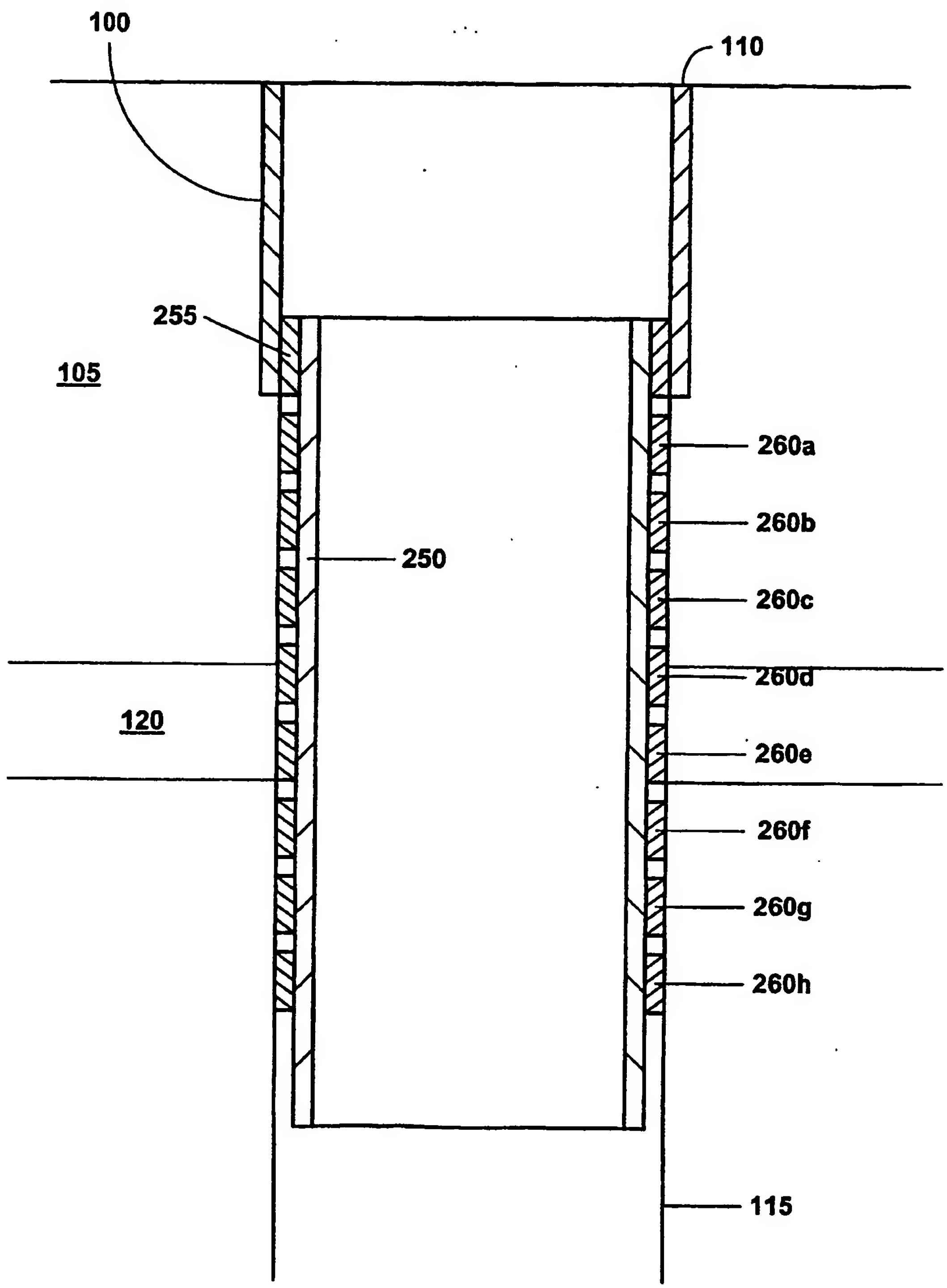

100
110
255
105
260a
260b
250
260c
260d
120
260e
260f
260g
260h
115

FIGURE 7

COUPLING AN EXPANDABLE LINER TO A WELLBORE CASING

This invention relates to coupling an expandable liner to a wellbore casing.

Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming wellbores and wellheads.

Summary of the Invention

According to the present invention there is provided in a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the solid tubular liner within the wellbore, preventing a portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the method further comprises:

during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore; and

preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

According to another aspect of the present invention there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore proximate the porous subterranean zone, maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing proximate the porous subterranean zone.

Preferably, the expansion device comprises an expansion cone.

Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

Preferably, maintaining the longitudinal centerline of the expansion device during the radial expansion comprises placing a plurality of standoffs about the solid tubular liner.

According to another aspect of the present invention there is provided in a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

means for positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

means for radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the system further comprises:

means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, the means for radially expanding the solid tubular liner comprises a means for injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

Preferably, the means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone comprises a plurality of standoffs about the solid tubular liner.

According to a further aspect of the present invention, there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a

tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

means for positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

means for, during the positioning of the portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore, maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing;

means for radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, the means for radially expanding the solid tubular liner comprises a means for injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

Preferably, the means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing during the radial expansion of the portion of the solid tubular liner comprises a plurality of standoffs about the solid tubular liner.

According to another aspect of the present invention, there is provided an apparatus for coupling a tubular liner to a wellbore casing within a wellbore that traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, comprising:

a tubular support member defining a first internal passage;

an expansion device coupled to the tubular support member defining a second internal passage fluidicly coupled to the first internal passage;

a tubular expansion device launcher movably coupled to and mating with the expansion device;

a solid tubular liner coupled to an end of the tubular expansion device launcher; and

a shoe coupled to another end of the tubular expansion device launcher including a valveable passage;

means for, during a positioning of the solid tubular liner within the wellbore, preventing a portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the wellbore during a radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the apparatus further comprises:

means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, the means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the wellbore during a radial expansion of the portion of the solid tubular liner comprises a plurality of standoffs about the solid tubular liner.

According to another aspect of the present invention, there is provided an apparatus for coupling a tubular liner to a wellbore casing within a wellbore that

traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, comprising:

a tubular support member defining a first internal passage;

an expansion device coupled to the tubular support member defining a second internal passage fluidicly coupled to the first internal passage;

a tubular expansion device launcher movably coupled to and mating with the expansion device;

a tubular liner coupled to an end of the tubular expansion device launcher;

a shoe coupled to another end of the tubular expansion device launcher including a valveable passage;

means for, during a positioning of a portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore, maintaining a longitudinal center line of the expansion device in a position that is substantially coincident with a longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing; and

means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the solid tubular liner during a longitudinal displacement of the expansion device relative to the tubular liner.

Preferably, the expansion device comprises an expansion cone.

Preferably, the means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the solid tubular liner during a longitudinal displacement of the expansion device comprises a plurality of standoffs about the solid tubular liner.

According to another aspect of the present invention, there is provided in a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing, wherein the solid tubular liner includes a resilient helical standoff coupled to the exterior surface of the solid tubular liner;

during the positioning of the solid tubular liner within the wellbore, the resilient helical standoff preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner;

and the resilient helical standoff preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

According to another aspect of the present invention, there is provided in a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing, wherein the solid tubular liner includes a plurality of spaced apart resilient standoffs coupled to the exterior surface of the solid tubular liner between the opposite ends of the solid tubular liner;

during the positioning of the solid tubular liner within the wellbore, the resilient standoffs preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

the resilient standoffs preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

According to another aspect of the present invention, there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

determining that the uncased section traverses a porous subterranean zone;

determining that the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone;

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

According to another aspect of the present invention, there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

determining that the uncased section traverses a porous subterranean zone;

determining that the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone;

if the uncased section is determined to traverse a porous subterranean zone having an operating pressure that is less than the operating pressure of the wellbore, then adding a passive structural means to the solid tubular liner;

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the solid tubular liner within the wellbore, the passive structural means preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

the passive structural means preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the

wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

Brief Description of the Drawings

FIG. 1 is a cross-sectional view illustrating a wellbore including a wellbore casing and an open hole section that traverses a porous subterranean layer.

FIG. 2 is a fragmentary cross-sectional view illustrating the introduction of an apparatus for casing the open hole section of the wellbore of FIG. 1.

FIG. 3 is a fragmentary cross-sectional view illustrating the injection of a fluidic material into the apparatus of FIG. 2.

FIG. 4 is a fragmentary cross-sectional view illustrating the placement of a plug into the exhaust passage of the shoe of the apparatus of FIG. 3.

FIG. 5 is a fragmentary cross-sectional view illustrating the pressurization of the interior portion of the apparatus below the expansion cone of FIG. 4.

FIG. 6 is a fragmentary cross-sectional view illustrating the completion of the radial expansion of the tubular member of the apparatus of FIG. 5.

FIG. 7 is a fragmentary cross-sectional view illustrating the removal of the shoe from the apparatus of FIG. 6.

Detailed Description of the Illustrative Embodiments

An apparatus and method for casing an open hole section of a wellbore within a subterranean formation is provided. The apparatus and method provides a system for casing an open hole section of a wellbore within a subterranean formation in which a tubular member having a plurality of radially oriented standoffs is radially expanded into contact with the preexisting wellbore casing and the open hole section. The standoffs provided on the exterior surface of the tubular member preferably position the tubular member away from the interior walls of the open hole section during the radial expansion process. In this manner, the tubular member does not adhere to underpressurized sections of the open hole

section of the wellbore. In this manner, the process of radial expansion is more reliable.

Referring initially to Fig. 1, a wellbore 100 positioned within a subterranean formation 105 includes a preexisting casing 110 and an open hole section 115 that traverses an porous region 120. When the operating pressure within the wellbore P_{BORE} is greater than the operating pressure within the porous region P_{PORE}, fluidic materials will flow from the wellbore 100 into the porous region 120. As a result of the flow of fluidic materials from the wellbore 100 into the porous region 120, downhole equipment will tend to adhere to, or at least be drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. This can have serious and adverse consequences when radially expanding a tubular member in such an operating environment.

Referring to Fig. 2, an apparatus 200 for forming a wellbore casing in the open hole section of the wellbore 100 may then be positioned within the wellbore in an overlapping relationship with the lower portion of the preexisting wellbore casing 110.

The apparatus 200 includes a tubular support member 205 having a longitudinal passage 210 and a transverse passage 215 that is coupled to an expansion cone 220 having a longitudinal passage 225 that is fluidicly coupled to the longitudinal passage 210. The expansion cone 220 is at least partially received within an expansion cone launcher 230 that includes a thin-walled annular member 235 and a shoe 240 having an exhaust passage 245. An expandable tubular member 250 extends from the expansion cone launcher 230 that includes a sealing member 255 and a plurality of standoffs 260a-260h affixed to the exterior surface of the expandable tubular member. In a preferred embodiment, the standoffs 260 are fabricated from a resilient material. A sealing cup 265 is attached to the exterior surface of the tubular support member 205 for preventing foreign materials from entering the interior of the expandable tubular member 250.

In a preferred embodiment, the apparatus 200 is provided as disclosed in one or more of the following: (1) U.S. patent 6,328,113 issued December 11, 2001, and filed as application serial no. 09/440,338, attorney docket number 25791.9.02, filed on 11/15/1999, which claimed benefit of the filing date of U.S.

provisional patent application serial number 60/108,558, attorney docket number 25791.9, filed on 11/16/1998, (2) U.S. patent 6,497,289, issued December 24, 2002, and filed as application serial no. 09/454,139, attorney docket number 25791.3.02, filed on 12/3/1999, which claimed benefit of the filing date of U.S. provisional patent application serial number 60/111,293, filed on 12/7/1998, (3) U.S. patent application serial number 09/502,350, attorney docket number 25791.8.02, filed on 2/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/119,611, attorney docket number 25791.8, filed on 2/11/1999, (4) U.S. patent application serial number 09/510,913, attorney docket number 25791.7.02, filed on 2/23/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,702, attorney docket number 25791.7, filed on 2/25/1999, (5) U.S. patent 6,575,240 issued June 10, 2003, and filed as application serial number 09/511,941, attorney docket number 25791.16.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application number 60/121,907, attorney docket number 25791.16, filed on 2/26/1999, (6) U.S. patent application serial number 09/523,460, attorney docket number 25791.11.02, filed on 3/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/124,042, attorney docket number 25791.11, filed on 3/11/1999, (7) U.S. patent 6,604,763, issued August 12, 2003, and filed as application serial number 09/559,122, attorney docket number 25791.23.02, filed on 4/26/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/131,106, attorney docket number 25791.23, filed on 4/26/1999, (8) U.S. patent 6,557,640, issued May 6, 2003, and filed as application serial number 09/588,946, attorney docket number 25791.17.02, filed on June 7, 2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/137,998, attorney docket number 25791.17, filed on 6/7/1999, (9) U.S. provisional patent application serial number 60/143,039, attorney docket number 25791.26, filed on 7/9/1999, (10) U.S. provisional patent application serial number 60/146,203, attorney docket number 25791.25, filed on 7/29/1999; (11) U.S. provisional patent application serial number 60/183,546, attorney docket number 25791.10, filed on 2/18/2000; (12)

U.S. patent 6,568,471 issued May 27, 2003, and filed as application serial number 09/512,895, attorney docket number 25791.12.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,841, attorney docket number 25791.12, filed on 2/26/1999; (13) U.S. provisional patent application serial number 60/212,359, attorney docket number 25791.38, filed on 6/19/2000; (14) U.S. provisional patent application serial number 60/162,671, attorney docket number 25791.27, filed on 11/1/1999; (15) U.S. provisional patent application serial number 60/159,039, attorney docket number 25791.36, filed on 10/12/1999; (16) U.S. provisional patent application serial number 60/159,033, attorney docket number 25791.37, filed on 10/12/1999; and (17) U.S. provisional patent application serial number 60/165,228, attorney docket number 25791.39, filed on 11/12/1999.

As illustrated in Fig. 2, during placement of the apparatus 200 within the wellbore 100, fluidic materials displaced by the apparatus 200 are conveyed through the longitudinal passages 210 and 225 to the transverse passage 215. In this manner, surge pressures during the placement of the apparatus 200 within the wellbore 100 are minimized. Furthermore, as illustrated in Fig. 2, the apparatus 200 is preferably initially positioned with upper portion of the tubular member 250 in opposing relation to the lower portion of the preexisting wellbore casing 110. In this manner, the upper portion of the tubular member 250 may be radially expanded into contact with the lower portion of the preexisting wellbore casing 110. In a preferred embodiment, during the placement of the apparatus 200 within the wellbore 100, the standoffs 260a-260h prevent the apparatus 200 from adhering to, or being drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. In this manner, the apparatus 200 is approximately centered within the wellbore 100.

As illustrated in Fig. 3, the transverse passage 215 may then be closed and fluidic materials injected into the apparatus 200 through the longitudinal passage 210. In this manner, any blockages within any of the passages 210, 225, and 245 may be detected by monitoring the operating pressure whereby an increase in operating pressure above nominal, or predetermined, conditions may indicate a blockage of one of the passages.

As illustrated in Fig. 4, a plug 270 or other conventional stop member may then be introduced into the fluidic materials injected into the apparatus 200 through the passage 210, and the plug 270 may be positioned within the exhaust passage 245. In this manner, the exhaust passage 245 may be sealed off. Thus, continued injection of fluidic materials into the apparatus 200 through the passage 210 may thereby pressurize a region 275 below the expansion cone 220.

As illustrated in Figs. 5 and 6, continued pressurization of the region 275 causes the expansion cone 220 to radially expand the expandable tubular member 250 off of the expansion cone. In this manner, the upper portion of the radially expanded tubular member 250 is coupled to the lower portion of the preexisting wellbore casing 110. In a preferred embodiment, during the radial expansion process, the tubular support member 205 is raised out of the wellbore 100.

In a preferred embodiment, throughout the radial expansion process, the standoffs 260a-260h prevent the exterior surface of the apparatus 200 from adhering to, or being drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. In this manner, the apparatus 200 is preferably substantially centered within the wellbore 100. Furthermore, in this manner, the longitudinal center axis of the expansion cone 220 is preferably maintained in a position that is substantially coincident with the longitudinal center axis of the tubular member 250. In addition, in this manner, the stresses applied to the interior surface of the tubular member 250 by the axial displacement of the expansion cone 220 are substantially even. Finally, in this manner, overstressing of the tubular member 250 is prevented thereby eliminating catastrophic failure of the tubular member 250.

As illustrated in Fig. 7, the shoe 240 may then be removed using a conventional milling device.

In a preferred embodiment, upon radially expanding the expandable tubular member 250, the standoffs 260a-260h seal and isolate intervals within the open hole section 115. In several alternative embodiments, the standoffs 260 may be provided, for example, by annular members spaced along the length of the expandable tubular member 250 and/or a continuous member that is wrapped around the expandable tubular member 250 in helical fashion.

It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the apparatus 200 may be used to form and/or repair, for example, a wellbore casing, a pipeline, or a structural support.

Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

1. In a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the solid tubular liner within the wellbore, preventing a portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

2. The method of claim 1, further comprising:

during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore; and

preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

3. The method of claim 1, wherein the expansion device comprises an

expansion cone.

4. The method of claim 1, wherein radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

5. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore proximate the porous subterranean zone, maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing proximate the porous subterranean zone.

6. The method of claim 5, wherein the expansion device comprises an expansion cone.

7. The method of claim 5, wherein radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

8. The method of claim 5, wherein maintaining the longitudinal centerline of the expansion device during the radial expansion comprises placing a plurality of standoffs about the solid tubular liner.

9. In a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

means for positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

means for radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

10. The system of claim 9, further comprising:

means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap

with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

11. The system of claim 9, wherein the expansion device comprises an expansion cone.

12. The system of claim 9, wherein the means for radially expanding the solid tubular liner comprises a means for injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

13. The system of claim 9, wherein the means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone comprises a plurality of standoffs about the solid tubular liner.

14. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

means for positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

means for, during the positioning of the portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore, maintaining the longitudinal center line of the expansion device in a position that is substantially

coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing;

means for radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

15. The system of claim 14, wherein the expansion device comprises an expansion cone.

16. The system of claim 14, wherein the means for radially expanding the solid tubular liner comprises a means for injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

17. The system of claim 14, wherein the means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing during the radial expansion of the portion of the solid tubular liner comprises a plurality of standoffs about the solid tubular liner.

18. An apparatus for coupling a tubular liner to a wellbore casing within a wellbore that traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, comprising:

a tubular support member defining a first internal passage;

an expansion device coupled to the tubular support member defining a second internal passage fluidicly coupled to the first internal passage;

a tubular expansion device launcher movably coupled to and mating with the expansion device;

a solid tubular liner coupled to an end of the tubular expansion device launcher; and

a shoe coupled to another end of the tubular expansion device launcher including a valveable passage;

means for, during a positioning of the solid tubular liner within the wellbore, preventing a portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the wellbore during a radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

19. The apparatus of claim 18, further comprising:

means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

20. The apparatus of claim 18, wherein the expansion device comprises an expansion cone.

21. The apparatus of claim 18, wherein the means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing

from contacting the porous subterranean zone of the wellbore during a radial expansion of the portion of the solid tubular liner comprises a plurality of standoffs about the solid tubular liner.

22. An apparatus for coupling a tubular liner to a wellbore casing within a wellbore that traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, comprising:

a tubular support member defining a first internal passage;

an expansion device coupled to the tubular support member defining a second internal passage fluidicly coupled to the first internal passage;

a tubular expansion device launcher movably coupled to and mating with the expansion device;

a tubular liner coupled to an end of the tubular expansion device launcher;

a shoe coupled to another end of the tubular expansion device launcher including a valveable passage;

means for, during a positioning of a portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore, maintaining a longitudinal center line of the expansion device in a position that is substantially coincident with a longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing; and

means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the solid tubular liner during a longitudinal displacement of the expansion device relative to the tubular liner.

23. The apparatus of claim 22, wherein the expansion device comprises an expansion cone.

24. The apparatus of claim 22, wherein the means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the solid tubular liner during a

longitudinal displacement of the expansion device comprises a plurality of standoffs about the solid tubular liner.

25. In a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing, wherein the solid tubular liner includes a resilient helical standoff coupled to the exterior surface of the solid tubular liner;

during the positioning of the solid tubular liner within the wellbore, the resilient helical standoff preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner;

and the resilient helical standoff preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

26. The method of claim 25, wherein the expansion device comprises an expansion cone.

27. The method of claim 25, wherein radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

21 5 04

28. In a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing, wherein the solid tubular liner includes a plurality of spaced apart resilient standoffs coupled to the exterior surface of the solid tubular liner between the opposite ends of the solid tubular liner;

during the positioning of the solid tubular liner within the wellbore, the resilient standoffs preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

the resilient standoffs preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

29. The method of claim 28, wherein the expansion device comprises an expansion cone.

30. The method of claim 28, wherein radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

31. In a wellbore that traverses a subterranean formation, the wellbore

including a cased section having a wellbore casing and an uncased section, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

determining that the uncased section traverses a porous subterranean zone;

determining that the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone;

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

32. The method of claim 31, wherein the expansion device comprises an expansion cone.

33. The method of claim 31, wherein radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

34. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

determining that the uncased section traverses a porous subterranean zone;

determining that the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone;

if the uncased section is determined to traverse a porous subterranean zone having an operating pressure that is less than the operating pressure of the wellbore, then adding a passive structural means to the solid tubular liner;

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the solid tubular liner within the wellbore, the passive structural means preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

the passive structural means preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

35. The method of claim 34, wherein the expansion device comprises an expansion cone.

36. The method of claim 34, wherein radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

37. A method of coupling a tubular liner to a wellbore casing substantially as described herein.

38. A system for coupling a tubular liner to a wellbore casing substantially as described herein with reference to and as illustrated in Figures 2 to

7 of the accompanying drawings.

39. An apparatus for coupling a tubular liner to a wellbore casing substantially as described herein with reference to and as illustrated in Figures 2 to 7 of the accompanying drawings.